INCORPORATION OF ENVIRONMENTAL IMPACT INDICES INTO NOISEMAP

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AFAMRL-TR-81-31

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FOR THE COMMANDER

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NOISEMAP and the General Purpose Contouring Program (GPCP) were modified to be compatible with the SITE II demographic data base and software program. This means that population and socio-economic status information from census tract tapes can be routinely obtained for noise contour areas generated using NOISEMAP. NOISEMAP Version 4.1 identifies to all users this new demographic overlay capability and the recent (Feb 80) update of the military aircraft noise data base (NOISEFILE) that revised the algorithm for predicting sound duration as a function of propagation distance.

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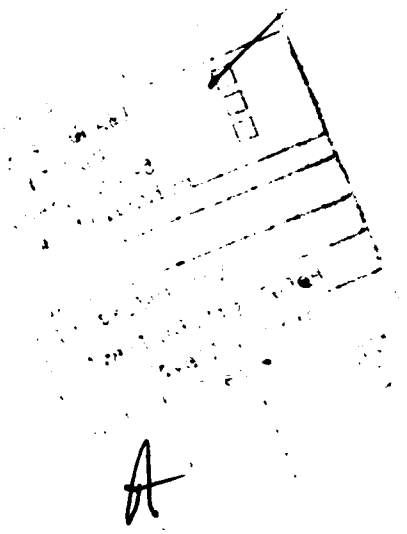
PREFACE

This research was performed for the Air Force Aerospace Medical Research Laboratory at Wright-Patterson Air Force Base, Ohio under Project/Task 723107, Technology to Define and Assess Environmental Quality of Noise From Air Force Operations. Technical monitor for this effort was Mr. Jerry D. Speakman of the Biodynamic Environment Branch, Biodynamics and Bioengineering Division. Funding for this effort was provided by the Air Force Engineering and Services Center, Directorate of Environmental Planning, Tyndall AFB, Florida.



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INTRODUCTION

The NOISEMAP computer program has been developed over the past several years for the Air Force.[1] This program calculates the day-night average sound levels based upon aircraft noise and performance data, and airport operational and flight path information. AMRL-TR-78-39, "Computer Aided Collection of Demographic Data Within Day-Night Level Contours: Two Test Cases,"[2] demonstrated that the output from NOISEMAP could be combined with a demographic package to calculate the population within each contour. The purpose of this study was to automate the process. This required the combining of two commercially available computer programs with NOISEMAP and generating some new computer programs to interface these programs.

TECHNICAL DISCUSSION

In order to obtain the demographic data for a particular air base, a series of computer programs are used. First NOISEMAP is called. NOISEMAP was modified to read and store the information needed to execute the demographics package. The only visible change to NOISEMAP is the Version number 4.1 and a new input card DEMOGR. The format of this card is given in Figure 1.

There are five data entries. The first two are the X and Y coordinates of a reference point on the airbase of interest. These are given in feet relative to the grid origin as are other locations used by NOISEMAP. The third and fourth fields are the longitude and latitude of the reference point given in degrees and fractional degrees. The fifth entry is used if the base is not oriented to the north. The rotational angle is given in degrees and fractional degrees with a positive number implying a clockwise rotation.

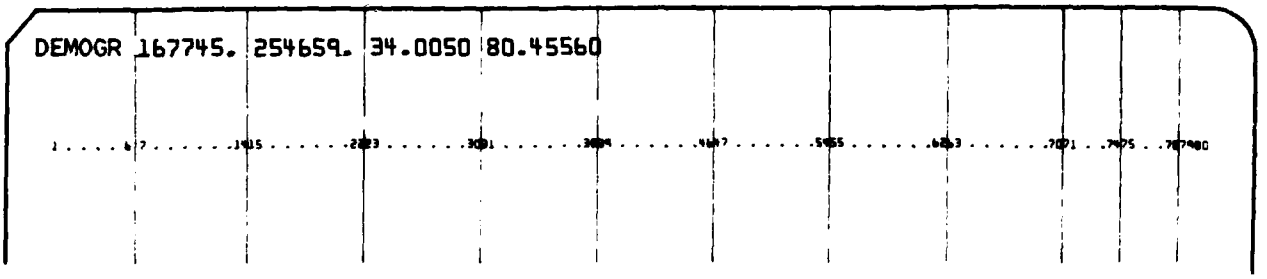
The DEMOGR card must be preceded by a PLOT card. NOISEMAP will then generate two tape files, TAPE8 and TAPE11. Both tapes are used by a contouring routine GPCPI1 (General Purpose Contouring Program) developed by California Computer Products Inc.[3] TAPE8 is also used by later routines.

The GPCPII program fits a surface to the grid of data points given it by NOISEMAP. After fitting the surface it calculates the locations of the various DNL contours specified on the PLOT card. GPCPII was modified so that the program outputs a file containing the X, Y coordinates of the points around each contour. These values are in inches of pen movement and must be scaled before using them. The values are stored on TAPE12 for further processing.

A new program named DEMOGR was developed to serve three purposes. First, GPCPII puts out up to several thousand points per contour. The demographics program SITEII will accept only 150 points per run. Therefore, the first task is to reduce the number of points to less than 150 points. This is done by calculating the slope between points and removing points in areas where the slope changes least.

The second purpose of DEMOGR is to close any open contours. This is accomplished by using the borders of the grided area as part of the contour. The final step is to reformat the data into

DEMOGR KEYWORD



Columns	
1 - 6	DEMOGR Keyword
7 - 14	X-coordinate of reference point (feet)
15 - 22	Y-coordinate of reference point (feet)
23 - 30	Latitude of reference point (degrees and fractional degrees)
31 - 38	Longitude of reference point (degrees and fractional degrees)
39 - 46	Rotational angle of air base. Positive indicates clockwise rotation form north (degrees and fractional degrees)

Figure 1. Format of Input Card DEMOGR

a form that is acceptable by the demographics computer program, SITEII.[4] This final output is placed on TAPE2. A second output is put on TAPE40. This contains information on the number of contours plotted.

A final computer program was written, XINDCS. This program reads the output files from the SITEII program and TAPE40 and prints out the population and number of households within each contour. The level weighted population and noise impact index are also calculated.

The Level Weighted Population and Noise Impact Index we calculate as defined in the guidelines[4] developed by CHABA Committee 69 of the National Academy of Science.[4] A weighting function was developed based upon social survey data relating the fraction of sampled population expressing a high degree of annoyance to various values of day-night average sound level.

The function is defined as follows:

$$W(L_{dn}) = \frac{[3.364 \times 10^{-6}][10^{0.103\ L_{dn}}]}{[0.2][10^{0.03\ L_{dn}}] + [1.43 \times 10^{-4}][10^{0.08\ L_{dn}}]}.$$

The weighting function is arbitrarily normalized to unity at 75 decibels. A tabular representation is given in Table 1. Level weighted populations in the programs prepared for the Air Force are calculated for each contour produced.

The Noise Impact Index is calculated as follows:

$$NII = \frac{LWP}{P_{TOTAL}} = \frac{\int P(Ldn) \cdot W(Ldn) d(Ldn)}{\int P(L_{dn}) d(L_{dn})}.$$

Ideally this would be summed over all noise levels for all persons exposed. For purposes of the Air Force report, this has been limited to a normal range of 60 or 65 L_{dn} to 85 L_{dn} in five dB steps. The total population for these reports is assumed to be the total population in the NOISEMAP grid area.

Appendix A has sample outputs from the SITEII program and the XINDCS program. The DEMOGR program output is designed for program testing and is not normally printed.

Appendix B contains a listing of the two new computer programs written.

TABLE 1

SOUND LEVEL WEIGHTING FUNCTION FOR OVERALL IMPACT ANALYSIS

The right hand column is included for convenience for finding the weighting of certain 5 dB increments.

L_{dn} -db	$W(L_{dn})$	$\frac{W(L_{dn}) + W(L_{dn} + 5)}{2}$
35	0.006	
		0.010
40	0.013	
		0.021
45	0.029	
		0.045
50	0.061	
		0.093
55	0.124	
		0.180
60	0.235	
		0.324
65	0.412	
		0.538
70	0.664	
		0.832
75	1.000	
		1.214
80	1.428	
		1.697
85	1.966	
		2.307
90	2.647	

APPENDIX A

INCORPORATION OF ENVIRONMENTAL IMPACT INDICES INTO NOISEMAP

```
DEMOGRAPHIC DATA

CONTOUR VALUE =     65
 1978 POPULATION =      12097
 1978 HOUSEHOLDS =       3754

CONTOUR VALUE =     70
 1978 POPULATION =       6334
 1978 HOUSEHOLDS =       1976

CONTOUR VALUE =     75
 1978 POPULATION =          9
 1978 HOUSEHOLDS =          2

CONTOUR VALUE =     80
 1978 POPULATION =          0
 1978 HOUSEHOLDS =          0

TOTALS FOR GRIDED AREA
 1978 POPULATION =      14637
 1978 HOUSEHOLDS         4842


LEVEL WEIGHTED POPULATION =      11797.32

NOISE IMPACT INDEX =                  .8060
```

SAMPLE XINDCS OUTPUT

65DNL

	DEGREES
LATITUDE	42.6120
LONGITUDE	82.8330

34 POINT POLYGON

WEIGHTING PCT 100%

		LATEST	CHANGE FROM 70
1978	POPULATION	12097	2259
1978	HOUSEHOLDS	3754	1010
1978	PER CAP INCOME	$ 4828	$ 1058
	ANNUAL COMPOUND GROWTH	3.5%	

1970 CENSUS DATA

POPULATION		
TOTAL	9838	100.0%
WHITE	9258	94.1%
NEGRO	544	5.5%
OTHER	36	0.4%
SPAN	124	1.3%

FAMILY INCOME (000)		
$0-5	369	15.5%
$5-7	287	12.0%
$7-10	418	17.5%
$10-15	688	28.8%
$15-25	525	22.0%
$25-50	77	3.2%
$50 +	24	1.0%
TOTAL	2388	
AVERAGE	$12042	
MEDIAN	$10872	

RENT		
$0-100	590	65.1%
$100-150	214	23.6%
$150-200	74	8.2%
$200-250	23	2.5%
$250 +	5	0.6%
TOTAL	906	
AVERAGE	$ 57	
MEDIAN	$ 77	
% RENTER	44.0	

UNITS IN STRUCTURE		
1	1409	51.2%
2	111	4.0%
3-4	76	2.8%
5-9	58	2.1%
10-49	443	16.1%
50 +	17	0.6%
MOBILE	638	23.2%

AGE AND SEX

	MALE		FEMALE		TOTAL
0-5	691	13.4%	658	14.1%	13.7%
6-13	839	16.2%	837	18.0%	17.0%
14-17	346	6.7%	305	6.5%	6.6%
18-20	281	5.4%	314	6.7%	6.0%
21-29	1114	21.5%	756	16.2%	19.0%
30-39	662	12.8%	610	13.1%	12.9%
40-49	545	10.5%	474	10.2%	10.4%
50-64	489	9.5%	484	10.4%	9.9%
65 +	206	4.0%	224	4.8%	4.4%
TOTAL	5173		4662		
MEDIAN(AGE)	24.5		23.6		24.1

HOME VALUE (000)		
$0-10	72	6.2%
$10-15	174	15.1%
$15-20	201	17.4%
$20-25	216	18.7%
$25-35	291	25.2%
$35-50	143	12.4%
$50 +	57	4.9%
TOTAL	1154	
AVERAGE	$25429	
MEDIAN	$23009	
% OWNER	56.0	

AUTOMOBILES		
NONE	93	3.4%
ONE	1576	57.5%
TWO	879	32.1%
THREE+	191	7.0%

HOUSEHOLDS WITH:		
TV	2569	93.6%
WASHER	2181	79.5%
DRYER	1758	64.1%
DISHWSH	536	19.5%
AIRCOND	288	10.5%
FREEZER	479	17.5%
2 HOMES	23	0.8%

OCCUPATION		
MGR/PROF	541	20.7%
SALES	208	7.9%
CLERICAL	470	18.0%
CRAFT	493	18.8%
OPERTIVS	477	18.2%
LABORER	105	4.0%
FARM	9	0.3%
SERVICE	301	11.5%
PRIVATE	13	0.5%

EDUCATION	ADULTS > 25	
0-8	890	19.8%
9-11	985	21.9%
12	1960	43.5%
13-15	367	8.2%
16 +	300	6.7%

HOUSEHOLD PARAMETERS		
FAM POP	8773	89.2%
INDIVIDS	432	4.4%
GRP QTRS	633	6.4%
TOT POP	9838	
NO OF HH'S	2744	
NO OF FAM'S	2393	
AVG HH SIZE	3.4	
AVG FAM SIZE	3.7	

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SAMPLE SITEII OUTPUT

APPENDIX B

COMPUTER PROGRAM LISTINGS

```
      PROGRAM XINDCS (INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT,
     1    TAPE8, TAPE40)
C
      REAL IWT
      REAL LWP,NN1
      DIMENSION TITLE(6), IDATA(89), ICNTR(100), NPOP(12), IPOP(12),
     1    IWT(12)
      DATA IY /1978/
      DATA IWT /0.0,.010,.021,.045,.093,.180,.324,.538,.832,
     1         1.214, 1.697, 2.307/
      NFILES =    0
      DO 5 I= 1,12
      IPOP(I) =0
      NPOP(I) = 0
    5 CONTINUE
   10 CONTINUE
      NFILES = NFILES+1
      READ (40) ICNTR(NFILES)
      IF(EOF(40)) 20,10
   20 CONTINUE
      NFILES = NFILES - 1
      IF (NFILES .LE. 100) GO TO 90
      WRITE(6,6000)
      STOP
C
C          READ DATA FROM FILE TAPE8 (SITEDAT)
C          NFILES = NUMBER OF FILES
C
   90 CONTINUE
      WRITE (6,6001)
      DO 1000 IFL = 1, NFILES
C
C          SITE11 PUTS OUT DATA FOR A RUN, SITE, AND CASE FOR EACH
C          CONTOUR. FOR THIS APPLICATION ALL 3 SETS OF DATA ARE
C          IDENTICAL. A 4TH READ IS ISSUED TO BRANCH ON EOF
C
      DO 100 IC= 1, 3
      READ (8,8000) IRUN, ISITE, ICASE, TITLE, IDATA
  100 CONTINUE
      READ (8,8000) IDUM
      IF(EOF(8)) 200,201
  200 CONTINUE
  201 CONTINUE
C
      IF (ICNTR(IFL).EQ. 0) GO TO 1050
```

```
      WRITE(6,6002) ICNTR(IFL),IY,IDATA(85),IY,IDATA(86)
      INDEX = (ICNTR(IFL) - 35) /5 +2
      IF(INDEX  .GT. 0) GO TO 300
      WRITE (6,6003) ICNTR(IFL)
      INDEX = 1
      GO TO 400
C
  300 CONTINUE
      IF (INDEX .LE. 12) GO TO 400
      WRITE(6,6004) ICNTR(IFL)
      INDEX = 12
  400 CONTINUE
C
C     STORE DATA IN PROPER REGISTER
C
      NPOP(INDEX) = NPOP(INDEX) + IDATA(85)
C
 1000 CONTINUE
 1050 CONTINUE
      WRITE(6,6005) IY, IDATA(85), IY, IDATA(86)
      NTOT = IDATA(85)
C
C         CALCULATE INCREMENTAL POPULATION
      IPOP(12) = NPOP(12)
      DO 1100 IC = 1,11
      ICR= 12-IC
      IF(NPOP(ICR) .LT. NPOP(ICR+1)) GO TO 1150
      IPOP(ICR) = NPOP(ICR) - NPOP(ICR + 1)
 1100 CONTINUE
 1150 CONTINUE
C
C
C         CALCULATE LEVEL WEIGHTED POPULATION
C
      LWP = 0
      DO 1200 IP = 1,12
      LWP = LWP + IWT(IP) * IPOP(IP)
 1200 CONTINUE
C
C         CALCULATE  NNI
C
      NNI = LWP/ NTOT
C
      WRITE (6,6006) LWP, NNI
      STOP
```

```
C          *******
C          FORMATS
C          *******
 6000 FORMAT (38H *** TOO MANY FILES NO PROCESSING *** )
 6001 FORMAT (1H1,10X,16HDEMOGRAPHIC DATA )
 6002 FORMAT (1HO,10X,16HCONTOUR VALUE =  ,I5  /
     1          11X,I5,14H POPULATION =  ,I10 /
     2          11X,I5,14H HOUSEHOLDS =  ,I10 )
 6003 FORMAT (1H , I5,2X, 36H CONTOUR DOES NOT CONTRIBUTE TO LWP )
 6004 FORMAT (1H , I5,2X, 38H CONTOUR TREATED AS 85 CONTOUR IN LWP )
 6005 FORMAT (1HO,10X,23HTOTALS FOR GRIDED AREA  /
     1          11X,I5,14H POPULATION =  ,I10 /
     2          11X,I5,14H HOUSEHOLDS =  ,I10 )
 6006 FORMAT (////11X,30H LEVEL WEIGHTED POPULATION =   ,F12.2//
     1            11X,22H NOISE IMPACT INDEX =   ,F20.4)
C
 8000 FORMAT(I1,2I3,6A4,/,11(8I9,/),I9)
C
      END
```

```
      PROGRAM DEMOGR(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT,TAPE1,
     1    TAPE2,TAPE12,TAPE8,TAPE40)
      WRITE(6,6100)
 6100 FORMAT(1H1)
C
C          SUBROUTINE SHORT REDUCES THE NUMBER OF POINTS GENERATED
C          BY GPCP TO LESS THAN 150 POINTS PER CONTOUR
C
      CALL SHORT
C
C          SUBROUTINE PRES2 CONVERTS THE DATA GENERATED BY
C          SHORT INTO A FORMAT READABLE BY THE SITEII PROGRAM
C
      CALL PRES2
       REWIND 40
      STOP
      END
      SUBROUTINE SHORT
      LOGICAL IEND
      DIMENSION X(10000),Y(10000)
C
      IEND=.FALSE.
      IOPEN=0
      NTEST= 0
      READ(12) ZTEST,IS,X(1),Y(1),IT
      NP=2
   50 CONTINUE
      READ(12) Z,IS1,X(NP),Y(NP),IT1
      IF(NP.GT.10000) GO TO 900
      IF(EOF(12)) 100,75
   75 CONTINUE
      IF(Z.NE.ZTEST .OR. IT1.NE.0) GO TO 110
      NP=NP+1
      GO TO 50
  100 CONTINUE
      IEND=.TRUE.
  110 CONTINUE
      NPT=NP
      NP=NP-1
      NMAX=149
      CALL REDU(X,Y,NP,NMAX)
C        CHECK TO DETERMINE IF OPEN CONTOUR
C
      IF(IT.EQ.5) GO TO 500
      WRITE(1) ZTEST,NP,IT
```

```
      DO 200 I=1,NP
      WRITE(1) X(I),Y(I)
  200 CONTINUE
C
  225 CONTINUE
      IF(IEND) 999,230
  230 CONTINUE
      NP=2
      X(1) = X(NPT)
      Y(1) = Y(NPT)
      IT=IT1
      IF(Z.EQ.ZTEST) GO TO 50
      ZTEST=Z
       IF(IOPEN.EQ.0) GO TO 50
      REWIND 2
      DO 300 I=1,IOPEN
      IF(NTEST.LT.140) GO TO 240
      XNT=NTEST
      RATIO = XNT/ 140.
      READ(2) ZT,NPTT,ITT
      DO 232 K=1,NPTT
      READ(2) X(K),Y(K)
  232 CONTINUE
      NMAX=RATIO * NPTT
      CALL REDU (X,Y,NPTT,NMAX)
      WRITE(1) ZT,NPTT,ITT
      DO 234 K=1,NPTT
      WRITE(1) X(K),Y(K)
  234 CONTINUE
      GO TO 300
  240  CONTINUE
      READ (2) ZT,NPTT,ITT
      WRITE(1) ZT,NPTT,ITT
      DO 250 J=1,NPTT
      READ (2) XT,YT
      WRITE(1) XT,YT
  250 CONTINUE
  300 CONTINUE
      NTEST=0
      IOPEN = 0
      REWIND 2
      GO TO 50
C
C       OPEN CONTOUR
C
```

```
 500 CONTINUE
     NTEST=NTEST+NP
     IOPEN=IOPEN+1
     WRITE(2) ZTEST,NP,IT
     DO 600 I=1,NP
     WRITE(2) X(I) , Y(I)
 600 CONTINUE
     GO TO 225
 999 CONTINUE
     REWIND 1
1000 CONTINUE
     READ(1) ZT,NP,IT
     IF(EOF(1)) 9999,1500
1500 CONTINUE
     WRITE(6,6000) ZT,NP
     DO 2000 I=1,NP
     READ(1) XT,YT
2000 CONTINUE
     GO TO 1000
 900 CONTINUE
     WRITE(6,6003) NP
     STOP
9999 CONTINUE
     RETURN
6000 FORMAT(10H CONTOUR:  ,F10.0, 20H NUMBER OF POINTS    ,I10)
6003 FORMAT( 16H TOO MANY POINTS  ,I10)
     END
     SUBROUTINE REDU(X,Y,NP,NMAX)
     DIMENSION X(10000),Y(10000),XN(10000),YN(10000)
     IF(NP.GT.10000) GO TO 900
     WRITE(6,6000) NP
     IF(NP.LE.NMAX) GO TO 500
     TEST=.001
  25 CONTINUE
     I1=1
     I2=2
     I3=3
     IN=0
      X1=X(I1)
     Y1=Y(I1)
     X2=X(I2)
     Y2=Y(I2)
     X3=X(I3)
     Y3=Y(I3)
  50 CONTINUE
```

```
      IF(Y1.EQ.Y2) GO TO 200
      IF(Y1.EQ.Y3) GO TO 200
      S1=(X1-X2)/(Y1-Y2)
      S2 = (X1-X3)/(Y1-Y3)
      IF(S2.EQ.0.) GO TO 200
      STEST=1.- ABS(S1/S2)
      STEST=ABS(STEST)
      IF( STEST.LT.TEST) GO TO 200
      IN=IN+1
      XN(IN) = X1
      YN(IN) = Y1
      X1=X2
      Y1=Y2
      X2=X3
      Y2=Y3
       I3=I3+1
      IF(I3.GT.NP) GO TO 300
      X3=X(I3)
      Y3=Y(I3)
      GO TO 50
  200 X2 = X3
      Y2=Y3
      I3=I3+1
      IF(I3.GT.NP) GO TO 300
      X3=X(I3)
      Y3= Y(I3)
C
      GO TO 50
  300 CONTINUE
      XN(IN+1) =X1
      YN(IN+1) =Y1
      IN=IN+2
      XN(IN) =X2
      YN(IN) = Y2
      DO 350 I=1,IN
      X(I)=XN(I)
      Y(I) =YN(I)
  350 CONTINUE
      NP=IN
      IF(NP.LE.NMAX) GO TO 500
      TEST=TEST+.001
      IF(TEST.GT.1.)  STOP 2
      GO TO 25
  500 CONTINUE
      RETURN
```

```
  900 CONTINUE
      WRITE(6,6001) NF
      STOP
 6000 FORMAT(28H ORIGINAL NUMBER OF POINTS =     ,I10)
 6001 FORMAT( 16H TOO MANY POINTS  ,I10)
      END
      SUBROUTINE PRES2
C
      DIMENSION AS(2,10)
      DIMENSION A(2,500)
      DIMENSION B(2,25,10),NPC(10),IORDER(10)
      DIMENSION IDLIM(4)
      EQUIVALENCE (A,B),(X,X1),(Y,Y1),(IM,ML)
      LOGICAL FIRST
      LOGICAL LAST
      DATA LAST/.F./
      DATA DTR/0.017453293/
      DATA MAXPT/149/
C
      DATA XCMNT /10HCMNT       /
      REWIND 8
      REWIND 1
   10 CONTINUE
      READ(8,8000) TITLE
 8000 FORMAT(A10)
      IF(TITLE.EQ.XCMNT)50,10
   50 CONTINUE
      READ(8,8001) TITLE,GX,GY,GRDSP,BX,BY,BLAT,BLON
 8001 FORMAT(A10,7F10.0)
      READ(8,8002) ANGLE,SCALE,IDLIM,NCON
 8002 FORMAT(2F10.0,5I10)
      CONV=SCALE/12.
      ANG = DTR * ANGLE
      CA = COS(ANG)
      SA = SIN(ANG)
C
C     ROTATE BASE POINT
C
      BXO = BX
      BYO = BY
      X = BX
      Y = BY
      BX = X*CA - Y*SA
      BY = X*SA + Y*CA
C
```

```
C          READ CONTOUR POINTS FORM TAPE 1
C
C      READ HEADER FIRST
100    CONTINUE
       READ(1) CONTOR,NP,IOPEN
       IF (EOF(1)) 900,110
C
C      READ POINTS
C
110    CONTINUE
       IF (IOPEN .EQ. 3 ) GO TO 500
       DO 120 N=1,NP
       READ(1) XX,YY
       A(1,N) = XX*CONV + GX
       A(2,N) = YY* CONV + GY
120    CONTINUE
C
C
C      FIND POINT WITH LOWEST X-VALUE
C
250    CONTINUE
       XMIN = 9999999999999.
       DO 260 I=1,NP
         IF (A(1,I) .GE. XMIN) GO TO 260
         XMIN = A(1,I)
         IND = I
260    CONTINUE
C
C      DETERMINE CLOCKWISE OR COUNTERCLOCKWISE
       T = (FLOAT(NP)) / 2.
       IT = IFIX(T)
       SUM = 0.
       IP = IND
       IM = IND
       IF (IND .GT. IT) GO TO 280
       DO 270 I=1,IT
         IP = IP + 1
         IM = IM - 1
         IF (IM .LT. 1) IM = NP
         SUM = SUM + A(2,IP) - A(2,IM)
270    CONTINUE
       GO TO 300
280    CONTINUE
       DO 290 I=1,IT
         IP = IP + 1
```

```
        IF (IP .GT. NP) IP = 1
        IM = IM - 1
        SUM = SUM + A(2,IP) - A(2,IM)
290   CONTINUE
300   CONTINUE
      IF (SUM) 320,320,310
310   CONTINUE
      IDIR = 1
      GO TO 350
320   CONTINUE
      IDIR = -1
C
C     NOW ROTATE POINTS  AND CONVERT TO DISPLACEMENT IN MILES
C
350   CONTINUE
      DO 370 I=1,NP
        X = A(1,I)
        Y = A(2,I)
        A(1,I) =(X*CA - Y*SA - BX) / 5280.
        A(2,I) =(X*SA + Y*CA - BY) / 5280.
370   CONTINUE
C
C
400   CONTINUE
C
C     READY TO WRITE RESULTS TO OUTPUT
C
      ICON=CONTOR
      WRITE(2,2000) TITLE,ICON
      WRITE(2,2001) TITLE,ICON,BLAT,BLON
      WRITE(2,2002) TITLE,ICON
      IF (IDIR .EQ. -1) GO TO 460
      DO 450 I=1,NP
        X = A(1,I)
        Y = A(2,I)
        CALL NSEW (X,Y)
450   CONTINUE
      WRITE(40) ICON
      ENDFILE 2
      GO TO 100
460   CONTINUE
      DO 490 J=1,NP
        I = NP - J + 1
        X = A(1,I)
        Y = A(2,I)
```

```
        CALL NSEW (X,Y)
490     CONTINUE
        WRITE(40) ICON
        ENDFILE 2
        GO TO 100
C
C
C       OPEN CONTOUR
C
500     CONTINUE
        WRITE(2,2000) TITLE,ICON
        WRITE(2,2001) TITLE,ICON,BLAT,BLON
        WRITE(2,2002) TITLE,ICON
        NL = 0
        NU = 0
        DO 505 J=1,500
          DO 505 I=1,2
            A(I,J) = 0.
505     CONTINUE
        DO 506 I=1,10
          IORDER(I) = 0
          NPC(I) = 0
506     CONTINUE
C
C       READ ALL OPEN SEGMENTS FOR  THIS CONTOUR
C
510     CONTINUE
          NU = NU + 1
          IF (NU .GT. 10) GO TO 990
          NL = NL + 1
          NPC(NU) = NP
          N = 0
          IT = IFIX(FLOAT(NP)/11.)
          N = NU + IT
          IF (N .GT. 10) GO TO 990
          DO 520 I=1,NP
        READ(1) XX,YY
        B(1,I,NU) = XX*CONV + GX
        B(2,I,NU) = YY*CONV + GY
520       CONTINUE
          NU = N
C
C         MUST ALLOW ONE EXTRA PLACE AT END OF EACH SEGMENT IN CASE IT IS
C           NECESSARY TO ADD A CORNER
C
```

```
        IF (MOD(NP,11) .NE. 0) GO TO 530
        NU = NU + 1
        NPC(NU) = 0
530     CONTINUE
C
C       READ NEXT HEADER
C
      READ(1) XCONTR,NP,NXOPEN
        IF (EOF(1)) 550,540
540     CONTINUE
        IF (XCONTR .NE. CONTOR) GO TO 550
        IF (NXOPEN .EQ. 6) GO TO 550
      GO TO 510
C
C     COMPUTE THE ORDER OF THE SEGMENTS FOR THIS OPEN CONTOUR
C
550   CONTINUE
      NPX = NP
      IT = 1
      IORDER(1) = 1
      ML = 1
      WRITE(40) ICON
      ENDFILE 2
      IF (IOPEN .EQ. 5 ) GO TO 500
      GO TO 110
C
C
560   CONTINUE
      X1 = B(1,NPC(ML),ML)
      Y1 = B(2,NPC(ML),ML)
      XE = B(1,1,ML)
      YE = B(2,1,ML)
570   CONTINUE
      DIST = 1.E+12
      DO 590 I=2,NU
        IF (I .EQ. ML) GO TO 590
        N = NPC(I)
        IF (N .LE. 0) GO TO 590
        X2 = B(1,1,I)
        Y2 = B(2,1,I)
        DI = (X1-X2)**2 + (Y1-Y2)**2
        IF (DI .GE. DIST) GO TO 580
        IF (DI .GE. ((XE-X2)**2+(YE-Y2)**2)) GO TO 580
        DIST = DI
        IND = I
```

```
580       CONTINUE
          X2 = B(1,N,I)
          Y2 = B(2,N,I)
          DI = (X1-X2)**2 + (Y1-Y2)**2
          IF (DI .GE. DIST) GO TO 590
          IF (DI .GE. ((XE-X2)**2+(YE-Y2)**2)) GO TO 590
          DIST = DI
          IND = -I
590     CONTINUE
        IT = IT + 1
        IORDER(IT) = IND
        IF (IT .EQ. NL) GO TO 600
        ML = IABS(IND)
        IF (IND .GT. 0) GO TO 560
        X1 = B(1,1,ML)
        Y1 = B(2,1,ML)
        XE = B(1,NPC(ML),ML)
        YE = B(2,NPC(ML),ML)
        GO TO 570
C
C       THROW OUT EXTRA POINTS
C
600     CONTINUE
        NP = 0
        DO 610 I=1,NU
          NP = NP + NPC(I)
610     CONTINUE
        IF (NP .LE. MAXPT) GO TO 670
        T = FLOAT(NP) / FLOAT(MAXPT)
        IT = IFIX(T)  + 1
        NP = 0
        DO 650 I=1,NU
          J = 1
          N = NPC(I)
          IF (N .LE. 0) GO TO 650
          FIRST = .F.
          K = 1 + IT
620       CONTINUE
            J = J + 1
            B(1,J,I) = B(1,K,I)
            B(2,J,I) = B(2,K,I)
            K = K + IT
            IF (K .LT. N)       GO TO 620
            IF (FIRST) GO TO 630
            FIRST = .T.
```

```
            K = N
          GO TO 620
630       CONTINUE
          NPC(I) = J
          NP = NP + J
650     CONTINUE
C
C       DETERMINE CLOCKWISE OR COUNTER CLOCKWISE FOR OPEN CONTOUR
C       AND CHECK TO SEE IF CORNERS NEED TO BE ADDED AS POLYGON POINTS
C
670     CONTINUE
        FIRST = .F.
        I1 = 1
        IA1 = 1
        I = 2
        X1 = B(1,NPC(IA1),IA1)
        Y1 = B(2,NPC(IA1),IA1)
675     CONTINUE
        I2 = IORDER(I)
        IF (I2) 680,805,685
680     CONTINUE
        IA2 = -I2
        X2 = B(1,NPC(IA2),IA2)
        Y2 = B(2,NPC(IA2),IA2)
        XE = B(1,1,IA2)
        YE = B(2,1,IA2)
        GO TO 690
C
685     CONTINUE
        IA2 = I2
        X2 = B(1,1,IA2)
        Y2 = B(2,1,IA2)
        XE = B(1,NPC(IA2),IA2)
        YE = B(2,NPC(IA2),IA2)
690     CONTINUE
        IF (X1 - X2) 720,700,730
C
C       EQUAL X-VALUES - NO NEED TO ADD A CORNER
700     CONTINUE
        IF (FIRST) GO TO 710
        IDIR = 1
        IF (X1 .NE. 0.) GO TO 715
        IF (Y1 .GT. Y2) IDIR = -1
        FIRST = .T.
710     CONTINUE
```

```
      I1 = I2
      IA1 = IA2
      I = I + 1
      X1 = XE
      Y1 = YE
      IF (I .GT. NL) GO TO 805
      GO TO 675
C
715   CONTINUE
      IF (Y1 .LT. Y2) IDIR = -1
      GO TO 710
C
720   CONTINUE
      IF (Y1 - Y2) 740,725,780
C
C     EQUAL Y VALUES - NO NEED TO ADD A CORNER
725   CONTINUE
      IF (FIRST) GO TO 710
      IDIR = 1
      IF (Y1 .EQ. 0.) IDIR = -1
      FIRST = .T.
      GO TO 710
C
730   CONTINUE
      IF (Y1 - Y2) 790,735,800
C
C     EQUAL Y VALUES - NO NEED TO ADD A CORNER
735   CONTINUE
      IF (FIRST) GO TO 710
      IDIR = 1
      IF (Y1 .NE. 0.) IDIR = -1
      FIRST = .T.
      GO TO 710
C
740   CONTINUE
      IF (X1 .EQ. 0.) GO TO 760
742   CONTINUE
      IF (FIRST) GO TO 745
      IDIR = -1
      FIRST = .T.
C
C     ADD CORNER (X2,Y1) TO END OF SEGMENT IA1
745   CONTINUE
      N = NPC(IA1)
      N = N + 1
```

```
      NPC(IA1) = N
      IF (I1 .LT. 0) GO TO 750
C     ADD CORNER TO BOTTOM OF LIST
      B(1,N,IA1) = X2
      B(2,N,IA1) = Y1
      GO TO 710
C     MOVE POINTS IN SEGMENT IA1 DOWN AND ADD CORNER TO TOP OF LIST
750   CONTINUE
      DO 755 K=1,N
        J = N - K + 1
        B(1,J,IA1) = B(1,J-1,IA1)
        B(2,J,IA1) = B(2,J-1,IA1)
755   CONTINUE
      B(1,1,IA1) = X2
      B(2,1,IA1) = Y1
      GO TO 710
C
760   CONTINUE
      IF (FIRST) GO TO 765
      IDIR = 1
      FIRST = .T.
C
C     ADD CORNER (X1,Y2) TO END OF SEGMENT IA1
765   CONTINUE
      N = NPC(IA1)
      N = N + 1
      NPC(IA1) = N
      IF (I1  .LT. 0) GO TO 770
C     ADD CORNER TO BOTTOM OF LIST
      B(1,N,IA1) = X1
      B(2,N,IA1) = Y2
      GO TO 710
C     MOVE POINTS IN SEGMENT IA1 DOWN AND ADD CORNER TO TOP OF LIST
770   CONTINUE
      DO 775 K=1,N
        J = N - K + 1
        B(1,J,IA1) = B(1,J-1,IA1)
        B(2,J,IA1) = B(2,J-1,IA1)
775   CONTINUE
      B(1,1,IA1) = X1
      B(2,1,IA1) = Y2
      GO TO 710
C
780   CONTINUE
      IF (X1 .EQ. 0) GO TO 785
```

```
      IF (FIRST) GO TO 745
      IDIR = 1
      FIRST = .T.
      GO TO 745
C
785   CONTINUE
      IF (FIRST) GO TO 765
      IDIR = -1
      FIRST = .T.
      GO TO 765
C
790   CONTINUE
      IF (X2 .EQ. 0.) GO TO 795
      IF (FIRST) GO TO 765
      IDIR = -1
      FIRST = .T.
      GO TO 765
C
795   CONTINUE
      IF (FIRST) GO TO 745
      IDIR = 1
      FIRST = .T.
      GO TO 745
C
800   CONTINUE
      IF (X2 .EQ. 0.) GO TO 742
      GO TO 760
C
805   CONTINUE
      IF (I .GT. NL+1) GO TO 810
      I = I + 1
      I2 = 1
      GO TO 685
C
C     ROTATE POINTS AND CONVERT TO DISPLACEMENT IN MILES
C
810   CONTINUE
      CA = COS(ANG)
      SA = SIN(ANG)
C
C     ROTATE BASE POINT
C
      BXO = BX
      BYO = BY
      X = BX
```

```
      Y = BY
      BX = X*CA - Y*SA
      BY = X*SA + Y*CA
      DO 820 I=1,NU
        N = NPC(I)
        IF (N .LE. 0) GO TO 820
        DO 815 J=1,N
          X = B(1,J,I)
          Y = B(2,J,I)
815     CONTINUE
820   CONTINUE
C
      DO 850 I=1,NL
        IT = IORDER(I)
        J = NL - I + 1
        IF (IDIR .EQ. -1) IT = IORDER(J) * (-1)
        IF (IT .LT. 0) GO TO 840
        N = NPC(IT)
        DO 835 J=1,N
          X = B(1,J,IT)
          Y = B(2,J,IT)
          CALL NSEW (X,Y)
835     CONTINUE
        GO TO 850
840     CONTINUE
        IT = -IT
        N = NPC(IT)
        DO 845 K=1,N
          J = N - K + 1
          X = B(1,J,IT)
          Y = B(2,J,IT)
          CALL NSEW (X,Y)
845     CONTINUE
850   CONTINUE
860   CONTINUE
      IF (IDIR .EQ. -1) GO TO 870
      X = B(1,1,1)
      Y = B(2,1,1)
      CALL NSEW (X,Y)
      GO TO 880
870   CONTINUE
      IT = IORDER(NL)
      IF (IT .LE. 0) GO TO 875
      X = B(1,NPC(IT),IT)
      Y = B(2,NPC(IT),IT)
```

```
      CALL NSEW(X,Y)
      GO TO 880
875   CONTINUE
      IT = -IT
      X = R(1,1,IT)
      Y = R(2,1,IT)
      CALL NSEW(X,Y)
880   CONTINUE
      IF (EOF(1)) 900,885
885   CONTINUE
      NP = NPX
      CONTOR = XCONTR
      IOPEN = NXOPEN
  900 CONTINUE
      IF(LAST) 950,940
  940 LAST=.T.
      CONTOR =0.
      A(1,1) = GX + (IDLIM(1)-1) * GRDSP
      A(2,1) = GY + (IDLIM(3)-1) * GRDSP
      A(1,2) = GX + (IDLIM(2)-1) * GRDSP
      A(2,2) = GY + (IDLIM(3)-1) * GRDSP
      A(1,3) = GX + (IDLIM(2)-1) * GRDSP
      A(2,3) = GY + (IDLIM(4)-1) * GRDSP
      A(1,4) = GX + (IDLIM(1)-1) * GRDSP
      A(2,4) = GY + (IDLIM(4)-1) * GRDSP
       NP=4
      GO TO 250
  950 CONTINUE
      RETURN
C
C     TOO MANY POINTS IN THIS CONTOUR
C
990   CONTINUE
      WRITE (6,6990) CONTOR
6990  FORMAT (10X,26HTOO MUCH DATA FOR CONTOUR   ,F9.0,
     1   / 5X,51HCHANGE THE THIRD DIMENSION OF ARRAY B AND TRY AGAIN  )
      STOP
 5001 FORMAT(A10)
 2000 FORMAT(2HA ,A10,2X,I5,5H DNL ,5X,1HX,23X,1HX,25X,2H  )
 2001 FORMAT(2HB ,A10,2X,I5,5H DNL ,19X,F7.4,3X,F8.4,18X,1H )
 2002 FORMAT(2HC ,A10,2X,I5,5H DNL ,55X,1H )
      END
      SUBROUTINE NSEW (X,Y)
      DATA JN/1HN/,JS/1HS/,JE/1HE/,JW/1HW/
C
```

```
      JNS = JN
      IF (Y .GE. 0.) GO TO 130
      Y = ABS(Y)
      JNS = JS
130   JEW = JE
      IF (X .GE. 0.) GO TO 150
      X = ABS(X)
      JEW = JW
  150 CONTINUE
      WRITE(2,2000) JNS,Y,JEW,X
 2000 FORMAT(1HD ,21X,A1,F5.2,2X,A1,F5.2,45X,1H )
      RETURN
      END
```

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